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(54) Title: N-AROYL PIPERAZINE DERIVATIVES AS OREXIN RECEPTOR ANTAGONISTS

(57) Abstract: This invention relates to N-aryl piperazine derivatives of formula (I), wherein: Y represents NR²; m represents 1, 2 or 3; p represents 0 or 1; X is O, S, C=O, SO₂, or CH=CH-; Ar¹ is aryl, or a mono or bicyclic heteroaryl group containing up to 4 heteroatoms selected from N, O and S; any of which may be optionally substituted; Ar² represents phenyl or a 5- or 6-membered heterocyclyl group containing 1 to 3 heteroatoms selected from N, O and S, wherein the phenyl heterocyclyl group is substituted by R¹ and further optional substituents; or Ar² represents an optionally substituted bicyclic aromatic or bicyclic heteroaromatic group containing 1 to 4 heteroatoms selected from N, O and S; R¹ represents optionally substituted (C₁₋₄)alkoxy, halo, optionally substituted (C₁₋₆)alkyl, optionally substituted phenyl, or an optionally substituted 5- or 6-membered heterocyclic ring containing 1 to 4 heteroatoms selected from N, O and S; R² represents hydrogen, optionally substituted (C₁₋₄)alkyl, optionally substituted (C₁₋₆)alkanoyl, optionally substituted (C₁₋₆)alkanoxycarbonyl or optionally substituted aryl(C₁₋₆)alkyloxycarbonyl; and their use as orexin receptor-antagonists.



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N-AROYL PIPERAZINE DERIVATIVES AS OREXIN RECEPTOR ANTAGONISTS

This invention relates to *N*-aroyl cyclic amine derivatives and their use as pharmaceuticals.

Many medically significant biological processes are mediated by proteins participating in
5 signal transduction pathways that involve G-proteins and/or second messengers.

Polypeptides and polynucleotides encoding the human 7-transmembrane G-protein coupled
neuropeptide receptor, orexin-1 (HFGAN72), have been identified and are disclosed in EP-A-
875565, EP-A-875566 and WO 96/34877. Polypeptides and polynucleotides encoding a second
human orexin receptor, orexin-2 (HFGANP), have been identified and are disclosed in EP-A-
10 893498.

Polypeptides and polynucleotides encoding polypeptides which are ligands for the orexin-1
receptor, e.g. orexin-A (Lig72A) are disclosed in EP-A-849361.

Orexin receptors are found in the mammalian host and may be responsible for many
biological functions, including pathologies including, but not limited to, depression; anxiety;
15 addictions; obsessive compulsive disorder; affective neurosis/disorder; depressive
neurosis/disorder; anxiety neurosis; dysthymic disorder; behaviour disorder; mood disorder; sexual
dysfunction; psychosexual dysfunction; sex disorder; sexual disorder; schizophrenia; manic
depression; delirium; dementia; severe mental retardation and dyskinesias such as Huntington's
disease and Gilles de la Tourette's syndrome; disturbed biological and circadian rhythms; feeding
20 disorders, such as anorexia, bulimia, cachexia, and obesity; diabetes; appetite/taste disorders;
vomiting/nausea; asthma; cancer; Parkinson's disease; Cushing's syndrome / disease; basophil
adenoma; prolactinoma; hyperprolactinemia; hypopituitarism; hypophysis tumor / adenoma;
hypothalamic diseases; Froehlich's syndrome; adrenohypophysis disease; hypophysis disease;
hypophysis tumor / adenoma; pituitary growth hormone; adrenohypophysis hypofunction;
25 adrenohypophysis hyperfunction; hypothalamic hypogonadism; Kallman's syndrome (anosmia,
hyposmia); functional or psychogenic amenorrhea; hypopituitarism; hypothalamic hypothyroidism;
hypothalamic-adrenal dysfunction; idiopathic hyperprolactinemia; hypothalamic disorders of
growth hormone deficiency; idiopathic growth hormone deficiency; dwarfism; gigantism;
acromegaly; disturbed biological and circadian rhythms; and sleep disturbances associated with
30 such diseases as neurological disorders, neuropathic pain and restless leg syndrome, heart and lung
diseases; acute and congestive heart failure; hypotension; hypertension; urinary retention;
osteoporosis; angina pectoris; myocardial infarction; ischaemic or haemorrhagic stroke;
subarachnoid haemorrhage; head injury such as sub-arachnoid haemorrhage associated with
traumatic head injury; ulcers; allergies; benign prostatic hypertrophy; chronic renal failure; renal
35 disease; impaired glucose tolerance; migraine; hyperalgesia; pain; enhanced or exaggerated
sensitivity to pain, such as hyperalgesia, causalgia and allodynia; acute pain; burn pain; atypical
facial pain; neuropathic pain; back pain; complex regional pain syndromes I and II; arthritic pain;
sports injury pain; pain related to infection, e.g. HIV, post-polio syndrome, and post-herpetic
neuralgia; phantom limb pain; labour pain; cancer pain; post-chemotherapy pain; post-stroke pain;
40 post-operative pain; neuralgia; conditions associated with visceral pain including irritable bowel
syndrome, migraine and angina; urinary bladder incontinence e.g. urge incontinence; tolerance to
narcotics or withdrawal from narcotics; sleep disorders; sleep apnea; narcolepsy; insomnia;
parasomnia; jet-lag syndrome; and neurodegenerative disorders, which includes nosological entities

such as disinhibition-dementia-parkinsonism-amyotrophy complex; pallido-ponto-nigral degeneration, epilepsy, and seizure disorders.

Experiments have shown that central administration of the ligand orexin-A (described in more detail below) stimulated food intake in freely-feeding rats during a 4 hour time period. This increase was approximately four-fold over control rats receiving vehicle. These data suggest that orexin-A may be an endogenous regulator of appetite. Therefore, antagonists of its receptor may be useful in the treatment of obesity and diabetes, see *Cell*, 1998, **92**, 573-585.

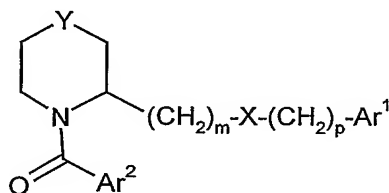
There is a significant incidence of obesity in westernised societies. According to WHO definitions a mean of 35% of subjects in 39 studies were overweight and a further 22% clinically obese. It has been estimated that 5.7% of all healthcare costs in the USA are a consequence of obesity. About 85% of Type 2 diabetics are obese, and diet and exercise are of value in all diabetics. The incidence of diagnosed diabetes in westernised countries is typically 5% and there are estimated to be an equal number undiagnosed. The incidence of both diseases is rising, demonstrating the inadequacy of current treatments which may be either ineffective or have toxicity risks including cardiovascular effects. Treatment of diabetes with sulfonylureas or insulin can cause hypoglycaemia, whilst metformin causes GI side-effects. No drug treatment for Type 2 diabetes has been shown to reduce the long-term complications of the disease. Insulin sensitisers will be useful for many diabetics, however they do not have an anti-obesity effect.

Rat sleep/EEG studies have also shown that central administration of orexin-A, an agonist of the orexin receptors, causes a dose-related increase in arousal, largely at the expense of a reduction in paradoxical sleep and slow wave sleep 2, when administered at the onset of the normal sleep period. Therefore antagonists of its receptor may be useful in the treatment of sleep disorders including insomnia.

The present invention provides *N*-aroyl cyclic amine derivatives which are non-peptide antagonists of human orexin receptors, in particular orexin-1 receptors. In particular, these compounds are of potential use in the treatment of obesity, including obesity observed in Type 2 (non-insulin-dependent) diabetes patients, and/or sleep disorders. Additionally these compounds are useful in stroke, particularly ischemic or haemorrhagic stroke, and/or blocking the emetic response i.e. the compounds are useful in the treatment of nausea and vomiting.

International Patent Applications WO99/09024, WO99/58533, WO00/47577 and WO00/47580 disclose phenyl urea derivatives and WO00/47576 discloses quinolinyl cinnamide derivatives as orexin receptor antagonists. WO01/96302 discloses *N*-aroyl cyclic amine derivatives and WO02/44172 discloses morpholine derivatives as orexin receptor antagonists.

According to the invention there is provided a compound of formula (I):



(I)

wherein:

Y represents NR²;

m represents 1, 2, or 3;

p represents 0 or 1;

X is O, S, C=O, SO₂, or -CH=CH-;

Ar¹ is aryl, or a mono or bicyclic heteroaryl group containing up to 4 heteroatoms selected from N, O and S; any of which may be optionally substituted;

Ar² represents phenyl or a 5- or 6-membered heterocyclyl group containing 1 to 3 heteroatoms selected from N, O and S, wherein the phenyl or heterocyclyl group is substituted by R¹ and further optional substituents; or Ar² represents an optionally substituted bicyclic aromatic or bicyclic heteroaromatic group containing 1 to 4 heteroatoms selected from N, O and S;

R¹ represents optionally substituted(C₁₋₄)alkoxy, halo, optionally substituted(C₁₋₆)alkyl, optionally substituted phenyl, or an optionally substituted 5- or 6-membered heterocyclic ring containing 1 to 4 heteroatoms selected from N, O and S;

R² represents hydrogen, optionally substituted (C₁₋₄)alkyl, optionally substituted (C₁₋₆)alkanoyl, optionally substituted (C₁₋₆)alkanoxycarbonyl or optionally substituted aryl(C₁₋₆)alkyloxycarbonyl;

or a pharmaceutically acceptable salt thereof.

Preferably where Ar² represents phenyl or a 5- or 6-membered heterocyclyl group containing up to 3 heteroatoms selected from N, O and S, the R¹ group is situated adjacent to the point of attachment to the amide carbonyl.

Preferably Ar¹ is aryl, or a mono or bicyclic heteroaryl group containing up to 3 heteroatoms selected from N, O and S; any of which may be optionally substituted.

R² can represent hydrogen, or optionally substituted (C₁₋₄)alkyl.

Preferably R² is hydrogen, methyl, ethyl, acetyl, trifluoroacetyl, methoxycarbonyl or benzyloxycarbonyl. More preferably R² is hydrogen, methyl or ethyl, even more preferably hydrogen or methyl.

Preferably Ar² represents phenyl or a 5- or 6-membered heterocyclyl group containing up to 3 heteroatoms selected from N, O and S, wherein the phenyl or heterocyclyl group is substituted by R¹ and further optional substituents; or Ar² represents an optionally substituted bicyclic aromatic or bicyclic heteroaromatic group containing up to 3 heteroatoms selected from N, O and S.

Preferably when R¹ represents an optionally substituted 5- or 6-membered heterocyclic ring it contains up to 3 heteroatoms selected from N, O and S.

Preferably R¹ is selected from trifluoromethoxy, methoxy, halo, or an optionally substituted phenyl, pyridinyl, pyrazolyl, oxadiazolyl, or pyrimidinyl group.

More preferably R¹ represents an optionally substituted phenyl, pyridinyl, pyrazolyl or oxadiazolyl or pyrimidinyl group.

Even more preferably R¹ represents an optionally substituted phenyl.

When Ar¹ is optionally substituted aryl it is preferably phenyl or naphthyl. The aryl group may have up to 5, preferably 1, 2 or 3 optional substituents.

When Ar¹ is a mono or bicyclic heteroaryl group it is for example quinoxaliny, quinazolinyl, pyridopyrazinyl, benzoxazolyl, benzothiophenyl, benzimidazolyl, naphthyridinyl, pyridinyl, pyrimidinyl, thiazolyl, or benzofuranyl.

Preferably Ar¹ is an optionally substituted phenyl.

Preferably m is 2 and p is 0.

Preferably X is O.

When Ar² or R¹ is a 5- or 6-membered heterocyclyl group containing up to 3 heteroatoms selected from N, O and S, it may be furanyl, thienyl, pyrrolyl, oxazolyl, thiazolyl, imidazolyl, oxadiazolyl, thiadiazolyl, pyridinyl, triazolyl, triazinyl, pyridazinyl, pyrimidinyl, isothiazolyl, isoxazolyl, pyrazinyl, or pyrazolyl.

When Ar² represents an optionally substituted bicyclic aromatic or bicyclic heteroaromatic group example are benzofuranyl, benzimidazolyl, quinolinyl, quinoxalinyl, or naphthyl.

Preferably Ar² represents optionally substituted phenyl, pyridinyl, thiazolyl, pyrazolyl, pyridazinyl, 1,2,3-triazolyl or naphthyl. Alternatively Ar² represents optionally substituted phenyl, pyridinyl, thiazolyl, pyrazolyl, pyridazinyl or 1,2,3-triazolyl.

Most preferably Ar² is thiazolyl.

Optional substituents for the groups Ar¹, Ar² and R¹ include halogen, hydroxy, oxo, cyano, nitro, (C₁₋₄)alkyl, (C₁₋₄)alkoxy, halo(C₁₋₄)alkyl, halo(C₁₋₄)alkoxy, aryl(C₁₋₄)alkoxy, (C₁₋₄)alkylthio, hydroxy(C₁₋₄)alkyl, (C₁₋₄)alkoxy(C₁₋₄)alkyl, (C₃₋₆)cycloalkyl(C₁₋₄)alkoxy, (C₁₋₄)alkanoyl, (C₁₋₄)alkoxycarbonyl, (C₁₋₄)alkylsulfonyl, (C₁₋₄)alkylsulfonyloxy, (C₁₋₄)alkylsulfonyl(C₁₋₄)alkyl, arylsulfonyl, arylsulfonyloxy, arylsulfonyl(C₁₋₄)alkyl, (C₁₋₄)alkylsulfonamido, (C₁₋₄)alkylamido, (C₁₋₄)alkylsulfonamido(C₁₋₄)alkyl, (C₁₋₄)alkylamido(C₁₋₄)alkyl, arylsulfonamido, arylcarboxamido, arylsulfonamido(C₁₋₄)alkyl, arylcarboxamido(C₁₋₄)alkyl, aroyl, aroyl(C₁₋₄)alkyl, or aryl(C₁₋₄)alkanoyl group; a group R³R⁴N-, R³OCO(CH₂)_r, R³CON(R⁴)(CH₂)_r, R³R⁴NCO(CH₂)_r, R³R⁴NSO₂(CH₂)_r or R³SO₂NR⁴(CH₂)_r, where each of R³ and R⁴ independently represents a hydrogen atom or a (C₁₋₄)alkyl group or where appropriate R³R⁴ forms part of a (C₃₋₆)azacycloalkane or (C₃₋₆)(2-oxo)azacycloalkane ring and r represents zero or an integer from 1 to 4. Additional substituents are (C₁₋₄)acyl, aryl, aryl(C₁₋₄)alkyl, (C₁₋₄)alkylamino(C₁₋₄)alkyl, R³R⁴N(CH₂)_n-, R³R⁴N(CH₂)_nO-, wherein n represents an integer from 1 to 4. Additionally when the substituent is R³R⁴N(CH₂)_n- or R³R⁴N(CH₂)_nO, R³ with at least one CH₂ of the (CH₂)_n portion of the group form a (C₃₋₆)azacycloalkane and R⁴ represents hydrogen, a (C₁₋₄)alkyl group or with the nitrogen to which it is attached forms a second (C₃₋₆)azacycloalkane fused to the first (C₃₋₆)azacycloalkane.

In addition Ar¹ may be optionally substituted by a phenyl ring optionally substituted by a halogen, cyano, C₁₋₄alkanoyl or C₁₋₄alkylsulfonyl group; or by a 5- or 6-membered heterocyclic ring, optionally substituted by a (C₁₋₂)alkyl or R³R⁴N- group; wherein R³ and R⁴ are as defined above.

Preferred optional substituents for Ar² include halogen, cyano, (C₁₋₄)alkanoyl and optionally substituted (C₁₋₆)alkyl.

Preferably Ar² is optionally substituted by halogen, cyano, or optionally substituted (C₁₋₆)alkyl.

Preferred optional substituents for Ar¹ include halogen.

Preferred compounds are selected from:

(RS)-2-(2-(4-Fluoro)phenoxyethyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-4-trifluoroacetyl piperazine;
 (RS)-4-Methyl-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl) piperazine;
 (RS)-2-(2-(4-Fluoro)phenoxyethyl)-1-((4-(2-methyl-5-phenyl)thiazolyl) carbonyl)piperazine;
 (RS)-4-Methyl-2-(2-phenoxyethyl)-1-((2-phenyl)benzamido)-piperazine;
 (RS)-4-(Benzyloxycarbonyl)-1-((2-(3-methyl-[1,2,4]-oxadiazol-5-yl)-phenyl)carbonyl)-2-(2-phenoxyethyl)piperazine;

(RS)-4-(Benzyloxycarbonyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine;
(RS)-4-(Methoxycarbonyl)-1-((2-phenyl)benzamido)-2-(2-phenoxyethyl)piperazine;
(RS)-4-(Methoxycarbonyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine;
(RS)-4-(Methoxycarbonyl)-1-((1-naphthyl)carbonyl)-2-(2-phenoxyethyl)piperazine;
(RS)-4-Acetyl-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine; or
(RS)-1-((2-Phenyl)benzamido)-2-(2-phenoxyethyl)piperazine acetate
and pharmaceutically acceptable salts thereof.

In the groups Ar¹ and Ar², substituents positioned *ortho* to one another may be linked to form a ring.

When a halogen atom is present in the compound of formula (I) it may be fluorine, chlorine, bromine or iodine. When the compound of formula (I) contains an alkyl group, whether alone or forming part of a larger group, e.g. alkoxy or alkylthio, the alkyl group may be straight chain, branched or cyclic, or combinations thereof, it is preferably methyl or ethyl.

When used herein the term aryl includes phenyl, or a 8- to 12- membered bicyclic ring system where at least one of the rings is aromatic for example naphthyl.

When X represents a group -CH=CH-, the compounds of formula (I) may exist as geometric isomers around the double bond. The present invention includes within its scope all such isomers, including mixtures.

It will be appreciated that compounds of formula (I) may exist as *R* or *S* enantiomers. The present invention includes within its scope all such isomers, including mixtures. Where additional chiral centres are present in compounds of formula (I), the present invention includes within its scope all possible diastereoisomers, including mixtures thereof. The different isomeric forms may be separated or resolved one from the other by conventional methods, or any given isomer may be obtained by conventional synthetic methods or by stereospecific or asymmetric syntheses.

It will be understood that the invention includes pharmaceutically acceptable derivatives of compounds of formula (I) and that these are included within the scope of the invention.

Particular compounds according to the invention include those mentioned in the examples and their pharmaceutically acceptable derivatives.

As used herein "pharmaceutically acceptable derivative" includes any pharmaceutically acceptable salt, ester or salt of such ester of a compound of formula (I) which, upon administration to the recipient is capable of providing (directly or indirectly) a compound of formula (I) or an active metabolic or residue thereof.

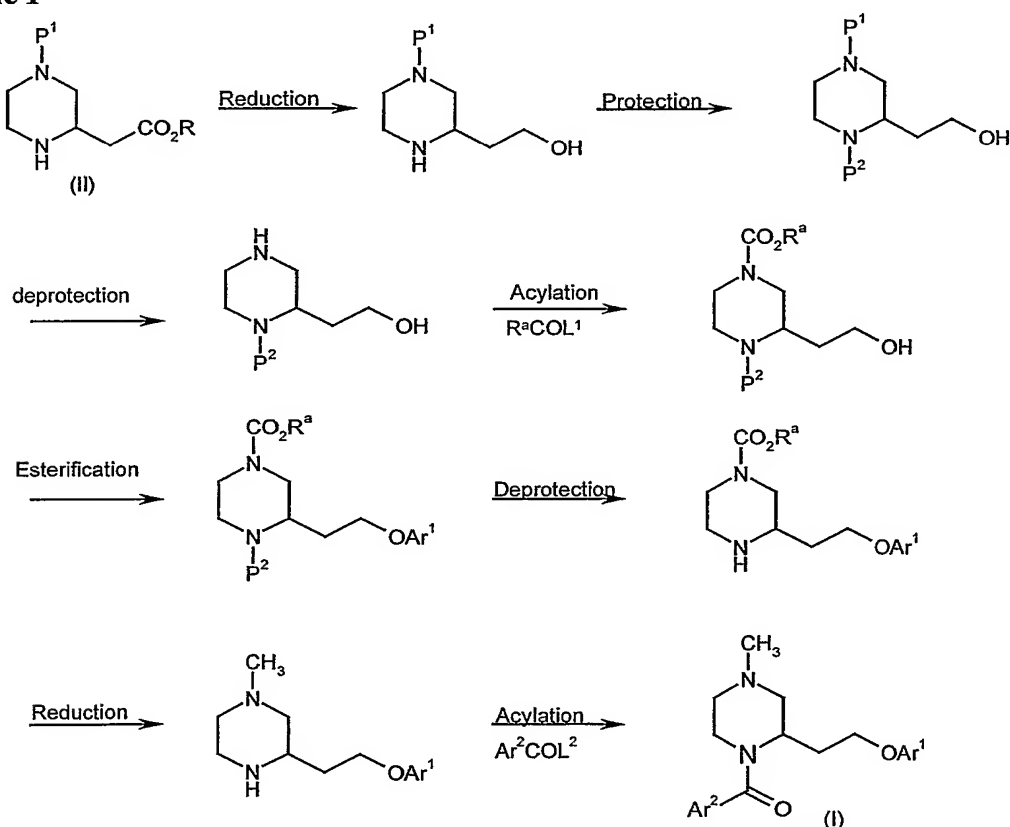
It will be appreciated that for use in medicine the salts of the compounds of formula (I) should be pharmaceutically acceptable. Suitable pharmaceutically acceptable salts will be apparent to those skilled in the art and include acid addition salts formed with inorganic acids e.g. hydrochloric, hydrobromic, sulphuric, nitric or phosphoric acid; and organic acids e.g. succinic, maleic, acetic, fumaric, citric, tartaric, benzoic, p-toluenesulfonic, methanesulfonic or naphthalenesulfonic acid. Other salts e.g. oxalates, may be used, for example in the isolation of compounds of formula (I) and are included within the scope of this invention. Also included within the scope of the invention are solvates and hydrates of compounds of formula (I).

Certain of the compounds of formula (I) may form acid addition salts with one or more equivalents of the acid. The present invention includes within its scope all possible stoichiometric and non-stoichiometric forms.

Since the compounds of formula (I) are intended for use in pharmaceutical compositions it will readily be understood that they are each preferably provided in substantially pure form, for example at least 60% pure, more suitably at least 75% pure and preferably at least 85%, especially at least 98% pure (% are on a weight for weight basis). Impure preparations of the compounds may be used for preparing the more pure forms used in the pharmaceutical compositions.

According to a further feature of the invention there is provided a process for the preparation of compounds of formula (I) and salts thereof. The following schemes detail some synthetic routes to compounds of the invention.

Scheme 1



wherein Ar^1 and Ar^2 are as defined for compounds of formula (I), R and R^a are optionally substituted alkyl groups, P^1 and P^2 are protecting groups and L^1 and L^2 are leaving groups.

Examples of protecting groups P^1 and P^2 include *t*-butoxycarbonyl, trifluoroacetyl, benzyloxycarbonyl and optionally substituted benzyl. Deprotection conditions will depend on the particular protecting group; for the groups mentioned above these are respectively, acid (e.g. trifluoroacetic acid in dichloromethane), base (e.g. potassium carbonate in a solvent such as aqueous methanol) and catalytic hydrogenolysis in an inert solvent (e.g. using palladium on charcoal in a lower alcohol or ethyl acetate).

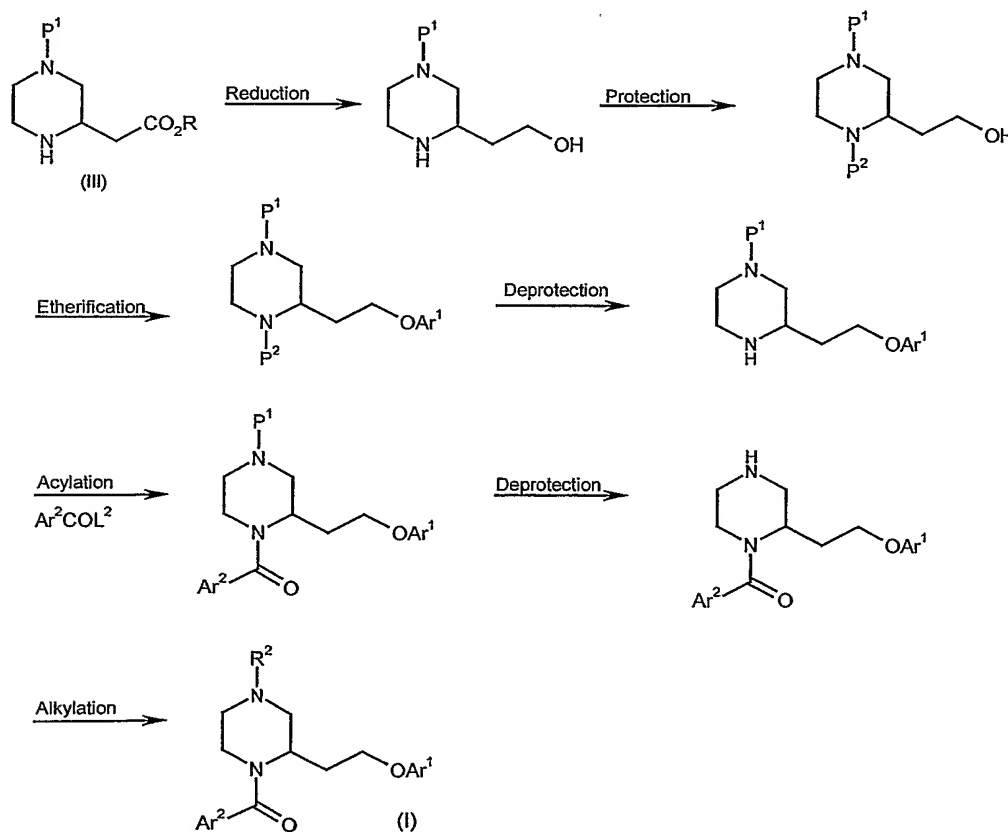
Examples of suitable leaving groups L^1 include halogen and for L^2 include halogen, hydroxy, $OC(=O)alkyl$ $OC(=O)O-alkyl$ and OSO_2Me . Acylation may be carried out using a wide range of known conditions, e.g. in an inert solvent such as dichloromethane, in the presence of a base such as triethylamine. Alternatively these steps may be carried out when L^2 represents hydroxy, in which case the reaction takes place in an inert solvent such as dichloromethane in the presence of a diimide reagent such as 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride, and an activator such as 1-hydroxy-benzo-triazole.

Reduction of the ester can be carried out using known methods e.g. with a metal hydride reducing agent such as lithium aluminium hydride in an inert solvent such as diethyl ether or tetrahydrofuran.

Etherification may be carried out using known methods e.g. under Mitsunobu conditions, i.e. in an inert solvent such as dichloromethane or tetrahydrofuran, in the presence of a phosphine reagent such as triphenylphosphine or tributylphosphine, and an azodicarbonyl reagent such as diethyl azodicarboxylate, diisopropyl azodicarboxylate, or 1,1'-azodicarbonyldipiperidine.

Included within the scope is protecting group interchange and use of optional protecting groups within Ar^1 , Ar^2 , R^1 , R^2 , and Y for example when Y is NH , preferably a protecting group is used.

Scheme 2



wherein Ar^1 , Ar^2 are as defined for formula (I), R^2 is an optionally substituted (C_{1-4}) alkyl, R is an optionally substituted alkyl group, P^1 and P^2 are protecting groups and L^2 is a leaving group as

defined for scheme 1. For compounds where R^2 is hydrogen the final alkylation step is not carried out.

N-Alkylation can be carried out using known conditions: e.g. reductive amination for example using formaldehyde and a metal hydride reducing agent such as sodium triacetoxyborohydride in an inert solvent such as 1,2-dichloromethane.

Within schemes 1 and 2 the protecting groups P^1 and P^2 are chosen to be different and there is scope for functional group interchange.

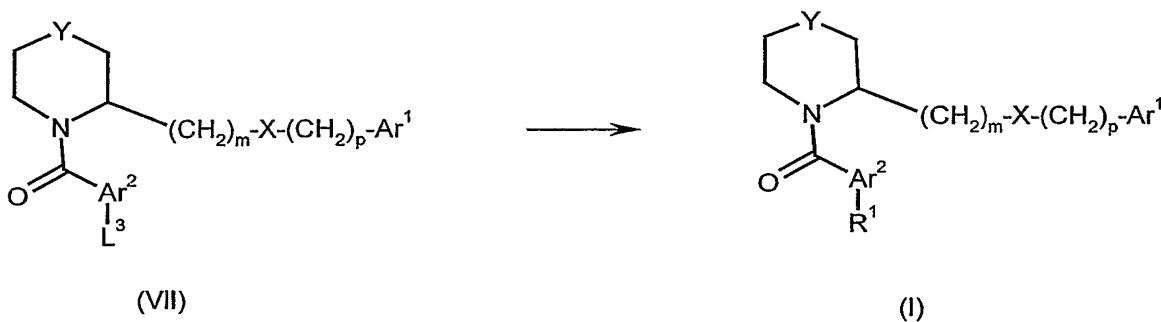
Included within the scope is protecting group interchange and use of optional protecting groups within Ar^1 , Ar^2 , R^1 , R^2 , and Y for example when Y is NH, preferably a protecting group is used.

Compounds of formula (II) and (III) are known in the literature or can be prepared by known methods.

Conversion of one compound of formula (I) to another of formula (I) by interconversion of substituents (including interconversions of the residue X) can be effected.

When R^1 is an aromatic group, the substituent R^1 may be introduced at the final stage as illustrated in Scheme 3 by reaction of a compound of formula (VII) where L^3 represents a leaving group such as halogen (preferably bromo or iodo) or trifluoromethylsulfonyloxy, and all other variables are as previously defined, with a reagent R^1M , where M is the residue of an organometallic species e.g. $B(OH)_2$ or trialkylstannyl. Such a process may be carried out in an inert solvent such as 1,2-dimethoxyethane or 1,4-dioxan, in the presence of a transition metal catalyst such as $Pd(PPh_3)_4$.

Scheme 3

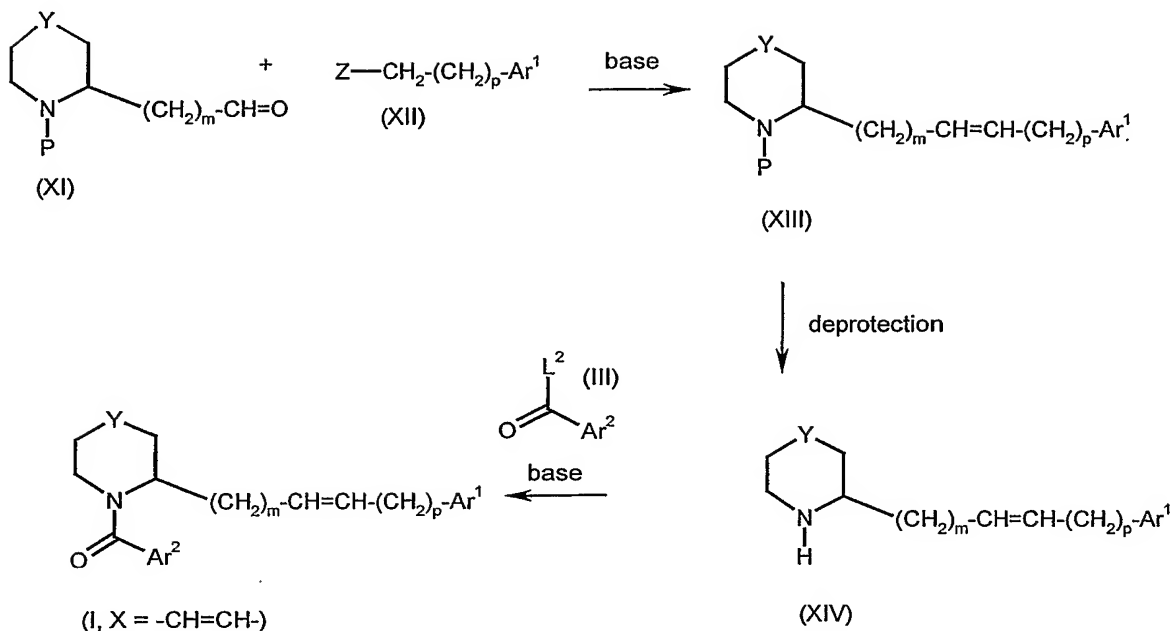


wherein Ar^2 , Ar^1 , X, m and p are as defined for formula (I) and R^1 is an aromatic group, Y is N-P wherein P is a protecting group, L^3 is a leaving group such as halogen (preferably bromo or iodo) or trifluoromethylsulfonyloxy.

Included within the scope is protecting group interchange and use of optional protecting groups within Ar^1 , Ar^2 , R^1 , R^2 , and Y for example when Y is NH, preferably a protecting group is used.

Compounds of formula (I) where X represents $-CH=CH-$ may be synthesised by the route shown in Scheme 4.

Scheme 4



where Z represents a group $[\text{P}^+(\text{aryl})_3][\text{Br}^-]$ or a group $\text{P}(=\text{O})(\text{Oalkyl})_2$, and all other variables are as previously defined.

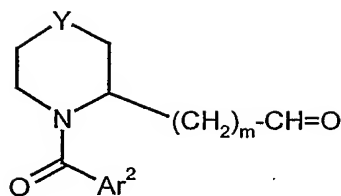
The reaction between (XI) and (XII) may be carried out in an inert solvent such as tetrahydrofuran, in the presence of a base such as butyllithium. Deprotection and final coupling steps can be carried out in a manner similar to those described in Scheme 1.

Included within the scope is protecting group interchange and use of optional protecting groups within Ar^1 , Ar^2 , R^1 , R^2 , and Y for example when Y is NH, preferably a protecting group is used.

Compounds of formula (XI) and (XII) are known in the literature or can be prepared by known methods.

Compounds of formula (I) where X is C=O may be prepared by: reaction of a compound of formula (XI) with a compound $\text{W}-(\text{CH}_2)_p\text{-Ar}^1$, where W is the residue of an organometallic species, e.g. Li- or BrMg- , in an inert solvent such as tetrahydrofuran; followed by oxidation of the resulting secondary alcohol with an oxidant such as Dess Martin periodinane in an inert solvent such as dichloromethane; then deprotection and coupling of the resultant secondary amine with a compound of formula (III) in the manner previously described.

Alternatively compounds of formula (I) where X is C=O may be prepared by reaction of a compound of formula (XV)



(XV)

wherein Y, m and Ar² are as defined for formula (I); with a compound W-(CH₂)_p-Ar¹ as defined above in an inert solvent such as tetrahydrofuran; followed by oxidation of the resulting secondary alcohol with an oxidant such as Dess Martin periodinane as described above.

5 Compounds of formula (XV) are known in the literature or can be prepared by known methods.

The compounds of formula (I) may be prepared singly or as compound libraries comprising at least 2, e.g. 5 to 1000, preferably 10 to 100 compounds of formula (I). Compound libraries may be prepared by a combinatorial 'split and mix' approach or by multiple parallel synthesis using either solution phase or solid phase chemistry, by procedures known to those skilled in the art.

10 Thus according to a further aspect of the invention there is provided a compound library comprising at least 2 compounds of formula (I), or pharmaceutically acceptable salts thereof.

The present invention also includes isotopically-labeled compounds, which are identical to those recited in formulas (I) and following, but for the fact that one or more atoms are replaced by an atom having an atomic mass or mass number different from the atomic mass or mass number usually found in nature. Examples of isotopes that can be incorporated into compounds of the invention include isotopes of hydrogen, carbon, nitrogen, oxygen, phosphorous, fluorine, iodine, and chlorine, such as ³H, ¹¹C, ¹⁴C, ¹⁸F, ¹²³I and ¹²⁵I.

Compounds of the present invention and pharmaceutically acceptable derivatives thereof of said compounds that contain the aforementioned isotopes and/or other isotopes of other atoms are within the scope of the present invention. Isotopically-labeled compounds of the present invention, for example those into which radioactive isotopes such as ³H, ¹⁴C are incorporated, are useful in drug and/or substrate tissue distribution assays. Tritiated, i.e., ³H, and carbon-14, i.e., ¹⁴C, isotopes are particularly preferred for their ease of preparation and detectability. ¹¹C and ¹⁸F isotopes are particularly useful in PET (positron emission tomography), and ¹²⁵I isotopes are particularly useful in SPECT (single photon emission computerized tomography), all useful in brain imaging. Further, substitution with heavier isotopes such as deuterium, i.e., ²H, can afford certain therapeutic advantages resulting from greater metabolic stability, for example increased *in vivo* half-life or reduced dosage requirements and, hence, may be preferred in some circumstances. Isotopically labeled compounds of formula (I) and following of this invention can generally be prepared by carrying out the procedures disclosed in the Schemes and/or in the Examples below, by substituting a readily available isotopically labeled reagent for a non-isotopically labeled reagent.

Pharmaceutically acceptable salts may be prepared conventionally by reaction with the appropriate acid or acid derivative.

35 The compounds of formula (I) and their pharmaceutically acceptable salts are useful for the treatment of diseases or disorders where an antagonist of a human orexin receptor is required such as obesity and diabetes; prolactinoma; hypoprolactinemia; hypothalamic disorders of growth hormone deficiency; idiopathic growth hormone deficiency; Cushing's syndrome/disease;

hypothalamic-adrenal dysfunction; dwarfism; sleep disorders; sleep apnea; narcolepsy; insomnia; parasomnia; jet-lag syndrome; sleep disturbances associated with diseases such as neurological disorders, neuropathic pain and restless leg syndrome; heart and lung diseases; depression; anxiety; addictions; obsessive compulsive disorder; affective neurosis/disorder; depressive
5 neurosis/disorder; anxiety neurosis; dysthymic disorder; behaviour disorder; mood disorder; sexual dysfunction; psychosexual dysfunction; sex disorder; sexual disorder; schizophrenia; manic depression; delirium; dementia; bulimia and hypopituitarism. The compounds of formula (I) or pharmaceutically acceptable derivatives thereof are also useful in the treatment of stroke, particular ischaemic or haemorrhagic stroke. Furthermore the compounds of formula (I) or pharmaceutically
10 acceptable derivatives useful in the blocking an emetic response.

The compounds of formula (I) and their pharmaceutically acceptable salts are particularly useful for the treatment of obesity, including obesity associated with Type 2 diabetes, and sleep disorders. Additionally the compounds are useful in stroke and/or blocking the emetic response i.e. nausea and vomiting.

15 Other diseases or disorders which may be treated in accordance with the invention include disturbed biological and circadian rhythms; adrenohypophysis disease; hypophysis disease; hypophysis tumor / adenoma; adrenohypophysis hypofunction; functional or psychogenic amenorrhea; adrenohypophysis hyperfunction; migraine; hyperalgesia; pain; enhanced or exaggerated sensitivity to pain such as hyperalgesia, causalgia and allodynia; acute pain; burn pain;
20 atypical facial pain; neuropathic pain; back pain; complex regional pain syndromes I and II; arthritic pain; sports injury pain; pain related to infection e.g. HIV, post-polio syndrome and post-herpetic neuralgia; phantom limb pain; labour pain; cancer pain; post-chemotherapy pain; post-stroke pain; post-operative pain; neuralgia; and tolerance to narcotics or withdrawal from narcotics.

The invention also provides a method of treating or preventing diseases or disorders where
25 an antagonist of a human orexin receptor is required, which comprises administering to a subject in need thereof an effective amount of a compound of formula (I), or a pharmaceutically acceptable derivative thereof.

The invention also provides a compound of formula (I), or a pharmaceutically acceptable derivative thereof, for use in the treatment or prophylaxis of diseases or disorders where an
30 antagonist of a human orexin receptor is required.

The invention also provides the use of a compound of formula (I), or a pharmaceutically acceptable derivative thereof, in the manufacture of a medicament for the treatment or prophylaxis of diseases or disorders where an antagonist of a human orexin receptor is required.

For use in therapy the compounds of the invention are usually administered as a
35 pharmaceutical composition. The invention also provides a pharmaceutical composition comprising a compound of formula (I), or a pharmaceutically acceptable derivative thereof, and a pharmaceutically acceptable carrier.

The compounds of formula (I) and their pharmaceutically acceptable derivative may be administered by any convenient method, e.g. by oral, parenteral, buccal, sublingual, nasal, rectal or
40 transdermal administration, and the pharmaceutical compositions adapted accordingly.

The compounds of formula (I) and their pharmaceutically acceptable derivative which are active when given orally can be formulated as liquids or solids, e.g. as syrups, suspensions, emulsions, tablets, capsules or lozenges.

A liquid formulation will generally consist of a suspension or solution of the active ingredient in a suitable liquid carrier(s) e.g. an aqueous solvent such as water, ethanol or glycerine, or a non-aqueous solvent, such as polyethylene glycol or an oil. The formulation may also contain a suspending agent, preservative, flavouring and/or colouring agent.

5 A composition in the form of a tablet can be prepared using any suitable pharmaceutical carrier(s) routinely used for preparing solid formulations, such as magnesium stearate, starch, lactose, sucrose and cellulose.

10 A composition in the form of a capsule can be prepared using routine encapsulation procedures, e.g. pellets containing the active ingredient can be prepared using standard carriers and then filled into a hard gelatin capsule; alternatively a dispersion or suspension can be prepared using any suitable pharmaceutical carrier(s), e.g. aqueous gums, celluloses, silicates or oils and the dispersion or suspension then filled into a soft gelatin capsule.

15 Typical parenteral compositions consist of a solution or suspension of the active ingredient in a sterile aqueous carrier or parenterally acceptable oil, e.g. polyethylene glycol, polyvinyl pyrrolidone, lecithin, arachis oil or sesame oil. Alternatively, the solution can be lyophilised and then reconstituted with a suitable solvent just prior to administration.

20 Compositions for nasal administration may conveniently be formulated as aerosols, drops, gels and powders. Aerosol formulations typically comprise a solution or fine suspension of the active ingredient in a pharmaceutically acceptable aqueous or non-aqueous solvent and are usually presented in single or multidose quantities in sterile form in a sealed container which can take the form of a cartridge or refill for use with an atomising device. Alternatively the sealed container may be a disposable dispensing device such as a single dose nasal inhaler or an aerosol dispenser fitted with a metering valve. Where the dosage form comprises an aerosol dispenser, it will contain a propellant which can be a compressed gas e.g. air, or an organic propellant such as a fluorochloro-
25 hydrocarbon or hydrofluorocarbon. Aerosol dosage forms can also take the form of pump-atomisers.

30 Compositions suitable for buccal or sublingual administration include tablets, lozenges and pastilles where the active ingredient is formulated with a carrier such as sugar and acacia, tragacanth, or gelatin and glycerin.

35 Compositions for rectal administration are conveniently in the form of suppositories containing a conventional suppository base such as cocoa butter.

Compositions suitable for transdermal administration include ointments, gels and patches.

Preferably the composition is in unit dose form such as a tablet, capsule or ampoule.

40 The dose of the compound of formula (I), or a pharmaceutically acceptable salt thereof, used in the treatment or prophylaxis of the abovementioned disorders or diseases will vary in the usual way with the particular disorder or disease being treated, the weight of the subject and other similar factors. However, as a general rule, suitable unit doses may be 0.05 to 1000 mg, more suitably 0.05 to 500 mg. Unit doses may be administered more than once a day for example two or three times a day, so that the total daily dosage is in the range of about 0.01 to 100 mg/kg; and such therapy may extend for a number of weeks or months. In the case of pharmaceutically acceptable salts the above figures are calculated as the parent compound of formula (I).

No toxicological effects are indicated/expected when a compound of formula (I) is administered in the above mentioned dosage range.

Human orexin-A has the amino acid sequence:

pyroGlu Pro Leu Pro Asp Cys Cys Arg Gln Lys Thr Cys Ser Cys Arg Leu

1 5 10 15

Tyr Glu Leu Leu His Gly Ala Gly Asn His Ala Ala Gly Ile Leu Thr

5 20 25 30

Leu-NH₂

Orexin-A can be employed in screening procedures for compounds which inhibit the ligand's activation of the orexin-1 receptor.

In general, such screening procedures involve providing appropriate cells which express the orexin-1 receptor on their surface. Such cells include cells from mammals, yeast, *Drosophila* or *E. coli*. In particular, a polynucleotide encoding the orexin-1 receptor is used to transfect cells to express the receptor. The expressed receptor is then contacted with a test compound and an orexin-1 receptor ligand to observe inhibition of a functional response. One such screening procedure involves the use of melanophores which are transfected to express the orexin-1 receptor, as described in WO 92/01810.

Another screening procedure involves introducing RNA encoding the orexin-1 receptor into *Xenopus* oocytes to transiently express the receptor. The receptor oocytes are then contacted with a receptor ligand and a test compound, followed by detection of inhibition of a signal in the case of screening for compounds which are thought to inhibit activation of the receptor by the ligand.

Another method involves screening for compounds which inhibit activation of the receptor by determining inhibition of binding of a labelled orexin-1 receptor ligand to cells which have the receptor on their surface. This method involves transfecting a eukaryotic cell with DNA encoding the orexin-1 receptor such that the cell expresses the receptor on its surface and contacting the cell or cell membrane preparation with a compound in the presence of a labelled form of an orexin-1 receptor ligand. The ligand may contain a radioactive label. The amount of labelled ligand bound to the receptors is measured, e.g. by measuring radioactivity.

Yet another screening technique involves the use of FLIPR equipment for high throughput screening of test compounds that inhibit mobilisation of intracellular calcium ions, or other ions, by affecting the interaction of an orexin-1 receptor ligand with the orexin-1 receptor.

All publications, including but not limited to patents and patent applications, cited in this specification are herein incorporated by reference as if each individual publication were specifically and individually indicated to be incorporated by reference herein as though fully set forth.

The following Examples illustrate the preparation of pharmacologically active compounds of the invention. The Descriptions D1-D20 illustrate the preparation of intermediates to compounds of the invention.

Description 1: *tert*-Butyl-N-(2-benzylaminoethyl)carbamate

Benzaldehyde (3.3 ml, 32.4 mmol) was added to a stirred solution of *tert*-butyl-N-(2-aminoethyl)carbamate (5.19g, 32.4 mmol) in 1,2-dichloroethane (50 ml). After stirring for 1 h sodium triacetoxymethylborohydride (10.3 g, 48.6 mmol) was added in two portions and the reaction mixture stirred at room temperature for a further 3h. Dichloromethane (300 ml) was added and the mixture washed with 1N sodium hydroxide. The organic layer was dried (Na₂SO₄) and evaporated *in vacuo*. The residue was chromatographed on silica gel eluting with 50 - 100% ethyl acetate in

hexane then 1 - 5 % methanol in ethyl acetate to afford the title compound (4.9 g, 60 %). Mass spectrum (AP^+): Found 251 (MH^+). $C_{14}H_{22}N_2O_2$ requires 250.

Description 2: (E)-Ethyl-[4-(N-benzyl-N-(2-*tert*-butyloxycarbonylaminoethyl))-amino] but-2-enoate

75% Ethyl-4-bromocrotonate (5.04 g, 19.6 mmol) was added to a stirred mixture of *tert*-butyl-N-(2-benzylaminoethyl)carbamate (D1) (4.9 g, 19.6 mmol), potassium carbonate (3.06 g, 21.56 mmol) and potassium iodide (3.25 g, 19.6 mmol) in anhydrous dimethylformamide (100 ml) at room temperature under argon. After stirring for 18 h the reaction mixture was poured into water (750 ml) and extracted with diethyl ether (3 x 200 ml). Combined extracts were washed with water (250 ml), brine (250 ml), dried (Na_2SO_4) and evaporated *in vacuo*. Chromatography on silica gel eluting with 0 - 30 % ethyl acetate in hexane gave the title compound as an orange oil (5.9 g 83 %). 1H NMR ($CDCl_3$) δ : 1.30 (3H, t, J = 7 Hz), 1.44 (9H, s), 2.56 (2H, t, J = 6 Hz), 3.10 - 3.30 (4H, m), 3.60 (2H, s), 4.20 (2H, q, J = 7 Hz), 4.80 (1H, broad m), 6.00 (1H, dd, J = 1, 16 Hz), 6.85 - 7.10 (1H, dt, J = 6, 16 Hz), 7.20 - 7.45 (5H, m).

Description 3: (RS)-Ethyl-(4-benzylpiperazin-2-yl)acetate

A solution of (E)-ethyl-[4-(N-benzyl-N-(2-*tert*-butyloxycarbonylaminoethyl))amino]but-2-enoate (D2) (5.9 g, 16.3 mmol) in dichloromethane (150 ml) and trifluoroacetic acid (30 ml) was stirred at room temperature for 2h. The mixture was evaporated *in vacuo* and the residue partitioned between saturated potassium carbonate and dichloromethane (100 ml each). The aqueous layer was extracted with dichloromethane (4 x 50 ml) and the combined organics dried (Na_2SO_4) and evaporated *in vacuo* to afford the title compound as a brown oil (4.36 g, 100 %). Mass spectrum (AP^+): Found 263 (MH^+). $C_{15}H_{22}N_2O_2$ requires 262.

Description 4: (RS)-4-Benzyl-2-(2-hydroxyethyl)piperazine

A 1M solution of lithium aluminium hydride in tetrahydrofuran (32.8 ml) was added dropwise to a stirred solution of (RS)-ethyl-(4-benzylpiperazin-2-yl)acetate (D3) (4.3 g, 16.41 mmol) in anhydrous tetrahydrofuran (100 ml) under argon, maintaining the temperature below 10°C. The resultant was stirred for a further 0.25 h, warmed to room temperature and stirred for 2.5 h. Water (8.2 ml), 2N sodium hydroxide (10.2 ml), and water (8.2 ml) were added dropwise sequentially with ice cooling. After 0.2 h sodium sulfate was added, the mixture stirred for 0.2 h then filtered through a short pad of celite. The filtrate was evaporated *in vacuo* to give the title compound as a pale orange oil (3.3 g, 91 %). Mass spectrum (AP^+): Found 221 (MH^+). $C_{13}H_{20}N_2O$ requires 220.

Description 5: (RS)-4-Benzyl-1-(*tert*-butyloxycarbonyl)-2-(2-hydroxyethyl)piperazine

A solution of di-*tert*-butyl dicarbonate (3.3 g, 15.12 mmol) in dichloromethane (10 ml) was added to a stirred solution of (RS)-4-benzyl-2-(2-hydroxyethyl)piperazine (D4) (3.3 g, 15 mmol) at room temperature and the resultant stirred for a further 18 h. Evaporation *in vacuo* and chromatography of the residue on silica gel eluting with 10 - 50 % ethyl acetate in hexane gave the title compound as a colourless oil (4.1 g, 85 %). Mass spectrum (AP^+): Found 321 (MH^+). $C_{18}H_{28}N_2O_3$ requires 320.

Description 6: (RS)-1-(*tert*-Butyloxycarbonyl)-2-(2-hydroxyethyl)piperazine

A solution of (RS)-4-benzyl-1-(*tert*-butyloxycarbonyl)-2-(2-hydroxyethyl)piperazine (D5) (2.5 g, 7.81 mmol) in ethanol (150 ml) was hydrogenated at atmospheric pressure and room temperature in the presence of 10 % palladium on charcoal (2.07 g, 54 % paste with water) for 3.5 h. The mixture was filtered through Kieselguhr and the filtrate evaporated *in vacuo* to give the title compound as a colourless oil (1.65 g, 92 %). Mass spectrum (AP^+): Found 231 (MH^+). $C_{11}H_{22}N_2O_3$ requires 230.

Description 7: (RS)-1-(*tert*-Butyloxycarbonyl)-2-(2-hydroxyethyl)-4-methoxycarbonylpiperazine

A solution of methyl chloroformate (0.52 ml, 6.73 mmol) in dichloromethane (5 ml) was added dropwise over 0.1 h to a stirred solution of (RS)-1-(*tert*-butyloxycarbonyl)-2-(2-hydroxyethyl)piperazine (D6) (1.4 g, 6.09 mmol) and triethylamine (1.7 ml, 12.2 mmol) in dichloromethane (45 ml) at 0°C under argon. The resultant mixture was stirred at room temperature for 18 h, washed with saturated sodium hydrogen carbonate and the organic layer dried (Na_2SO_4) and evaporated *in vacuo*. The residue was chromatographed on silica gel eluting with 10 - 100 % ethyl acetate in hexane to give the title compound as a colourless gum (1.36 g, 78 %). 1H NMR ($CDCl_3$) δ : 1.48 (9H, s), 1.60 - 1.95 (2H, m), 2.80 - 3.00 (2H, m), 3.05 - 3.45 (2H, m), 3.50 - 3.70 (2H, m), 3.70 (3H, s), 3.75 - 4.45 (4H, m).

Description 8: (RS)-1-(*tert*-Butyloxycarbonyl)-4-methoxycarbonyl-2-(2-phenoxyethyl)piperazine

A solution of diethyl azodicarboxylate (0.74 ml, 4.7 mmol) in anhydrous dichloromethane (3 ml) was added to a stirred, ice-methanol cooled solution of (RS)-1-(*tert*-butoxycarbonyl)-2-(2-hydroxyethyl)-4-methoxycarbonylpiperazine (D7) (1.35 g, 4.69 mmol), phenol (0.441 g, 4.69 mmol) and triphenylphosphine (1.23 g, 4.69 mmol) in anhydrous dichloromethane (40 ml). The mixture was stirred at room temperature for 18 h then evaporated *in vacuo*. The residue was chromatographed on silica gel eluting with 10 - 20 % ethyl acetate in hexane to give the title compound (1.43 g, 84 %). 1H NMR ($CDCl_3$) δ : 1.38 (9H, m), 1.85 - 2.20 (2H, m), 2.75 - 3.20 (3H, m), 3.72 (3H, s), 3.80 - 4.20 (5H, m), 4.39 (1H, broad m), 6.75 - 7.00 (3H, m), 7.15 - 7.35 (2H, m).

Description 9: (RS)-4-Methoxycarbonyl-2-(2-phenoxyethyl)piperazine

A solution of (RS)-1-(*tert*-butyloxycarbonyl)-4-methoxycarbonyl-2-(2-phenoxyethyl)piperazine (D8) (1.4 g, 3.85 mmol) in dichloromethane (30 ml) and trifluoroacetic acid (5 ml) was stirred at 35 °C for 0.75 h. On cooling, the mixture was evaporated *in vacuo* and the residue partitioned between dichloromethane and 1N sodium hydroxide (50 ml each). The organic layer was dried (Na_2SO_4) and evaporated *in vacuo* to afford the title compound as a colourless oil (1.01 g, 99 %). Mass spectrum (AP^+): Found 265 (MH^+). $C_{14}H_{20}N_2O_3$ requires 264.

Description 10: (RS)-4-Methyl-2-(2-phenoxyethyl)piperazine

A 1M solution of lithium aluminium hydride in tetrahydrofuran (7.6 ml) was added dropwise to a stirred solution of (RS)-4-methoxycarbonyl-2-(2-phenoxyethyl)piperazine (D9) (1 g, 3.79 mmol) in anhydrous tetrahydrofuran (30 ml) at 0°C under argon. The resultant mixture was stirred at 0°C for 0.25 h and at room temperature for a further 1.5 h. Water (1.25 ml), 2N sodium hydroxide (1.55 ml) and water (1.25 ml) were added dropwise sequentially with ice cooling. After 0.2 h sodium

sulphate was added, the mixture stirred for 0.2 h and then filtered through a short pad of celite. The filtrate was evaporated *in vacuo* to give the title compound as a colourless oil (0.73 g, 88 %). Mass spectrum (AP^+): Found 221 (MH^+). $C_{13}H_{20}N_2O$ requires 220.

5 **Description 11: (RS)-1-(*tert*-Butyloxycarbonyl)-2-(2-hydroxyethyl)-4-trifluoroacetyl-piperazine**

Trifluoroacetic anhydride (1.08 ml, 7.65 mmol) was added dropwise to a stirred solution of (RS)-1-(*tert*-butyloxycarbonyl)-2-(2-hydroxyethyl)piperazine (D6) (1.6 g, 6.96 mmol) and triethylamine (1.2 ml, 8.35 mmol) in anhydrous dichloromethane (50 ml) at 0 °C under argon. The reaction mixture was allowed to warm to room temperature over 2 h, then stirred for 68 h. The mixture was washed with saturated sodium hydrogen carbonate, dried (Na_2SO_4) and evaporated *in vacuo* to give the title compound as a colourless solid (2.03 g, 99 %). Mass spectrum (AP^+): Found 349 (MNa^+). $C_{13}H_{21}F_3N_2O_4$ requires 326.

15 **Description 12: (RS)-1-(*tert*-Butyloxycarbonyl)-2-(2-(4-fluoro)phenoxyethyl)-4-trifluoroacetyl piperazine**

The title compound was prepared using the method of Description 8, from (RS)-1-(*tert*-butyloxycarbonyl)-2-(2-hydroxyethyl)-4-trifluoroacetyl piperazine (D11) (0.805 g, 2.47 mmol) and 4-fluorophenol (0.277 g, 2.47 mmol) as a colourless gum (0.41 g, 39 %). Mass spectrum (AP^+): Found 443 (MNa^+). $C_{19}H_{24}F_4N_2O_4$ requires 420.

Description 13: (RS)-2-(2-(4-Fluoro)phenoxyethyl)-4-trifluoroacetyl piperazine

The title compound was prepared using the method of Description 9, from (RS)-1-(*tert*-butyloxycarbonyl)-2-(2-(4-fluoro)phenoxyethyl)-4-trifluoroacetyl piperazine (D12) (0.4 g, 0.95 mmol) as a pale yellow gum (0.16 g, 52 %). Mass spectrum (AP^+): Found 321 (MH^+). $C_{14}H_{16}F_4N_2O_2$ requires 320.

Description 14: (RS)-2-(2-Hydroxyethyl)-4-(benzyloxycarbonyl)-1-*tert*-butyloxy-carbonyl)piperazine

The title compound (2.0g, 91%) was obtained from the compound of D6 (1.4g, 6.09 mmol) and benzyl chloroformate (0.96ml, 6.70 mmol) according to the method of D7. Mass spectrum (AP^+): Found 265 ($MH-Boc^+$). $C_{19}H_{28}N_2O_5$ requires 364.

35 **Description 15: (RS)-4-(Benzyloxycarbonyl)-1-(*tert*-butyloxycarbonyl)-2-(2-phenoxyethyl)piperazine**

The title compound (2g, 83%) was obtained from the compound of D14 (2g, 5.49 mmol) and phenol (0.518g, 5.49 mmol) according to the method of D8. Mass spectrum (AP^+): Found 341 ($MH-Boc^+$). $C_{25}H_{32}N_2O_5$ requires 440.

40 **Description 16: (RS)-4-(Benzyloxycarbonyl)-2-(2-phenoxyethyl)piperazine**

The title compound (0.66g, 86%) was obtained from the compound of D15 (1g, 2.3 mmol) according to the method of D9. Mass spectrum (AP^+): Found 341 (MH^+). $C_{20}H_{24}N_2O_3$ requires 340.

Description 17: (RS)-1-(*tert*-Butyloxycarbonyl)-2-(2-phenoxyethyl)piperazine

To the compound from D15 (0.95g, 2.15 mmol) in ethanol (50 ml) was added 10% Pd/C catalyst (60 % aqueous paste) (0.43g) and the mixture hydrogenated at NTP for 3h. The resultant was filtered through kieselguhr, washing well with ethanol and the filtrate evaporated to afford the title product (0.64g, 97 %) as an oily gum. Mass spectrum (AP^+): Found 307 (MH^+). $C_{17}H_{26}N_2O_3$ requires 306.

Description 18: (RS)-4-Acetyl-1-(*tert*-butyloxycarbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.114g, 99 %) was obtained from the compound of D17 (0.100g, 0.33 mmol) and acetyl chloride (0.035 ml, 0.49 mmol) according to the method of Example 2. Mass spectrum (AP^+): Found 349 (MH^+). $C_{19}H_{28}N_2O_4$ requires 348.

Description 19: (RS)-4-Acetyl-2-(2-phenoxyethyl)piperazine

The title compound (0.074g, 99 %) was obtained from the compound of D18 (0.1g, 0.28 mmol) according to the method of D9. Mass spectrum (AP^+): Found 249 (MH^+). $C_{14}H_{20}N_2O_2$ requires 248.

Description 20: (RS)-4-(Benzyloxycarbonyl)-1-((2-phenyl)benzamido)-2-(2-phenoxyethyl)piperazine

The title compound (0.14g, 83 %) was obtained from the compound of D16 (0.11g, 0.324 mmol) and 2-phenylbenzoyl chloride (0.077g, 0.356 mmol) according to the method of Example 2. Mass spectrum (Electrospray LC/MS): Found 521 (MH^+). $C_{33}H_{32}N_2O_4$ requires 520.

Example 1: (RS)-2-(2-(4-Fluoro)phenoxyethyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-4-trifluoroacetyl piperazine

The title compound was prepared using the method of Example 2, from (RS)-2-(2-(4-fluoro)phenoxyethyl)-4-trifluoroacetyl piperazine (D13) (0.16 g, 0.5 mmol) as a pale orange gum (0.19 g, 73 %). Mass spectrum (AP^+): Found 522 (MH^+). $C_{25}H_{23}F_4N_3O_3S$ requires 521.

Example 2: (RS)-4-Methyl-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine

2-Methyl-5-phenylthiazole-4-carbonyl chloride (0.029 g, 0.12 mmol) in dichloromethane (1 ml) was added to a solution of (RS)-4-methyl-2-(2-phenoxyethyl)piperazine (D10) (0.022 g, 0.1 mmol) and triethylamine (0.042 ml, 0.3 mmol) in dichloromethane (2 ml), and the mixture shaken for 1 h. The reaction mixture was washed with saturated sodium hydrogen carbonate (3 ml). The organic layer was added directly onto a 10 g pre-packed silica gel cartridge and eluted with 0 - 100 % ethyl acetate in hexane to give the title compound as a colourless gum (0.021 g, 50 %). Mass spectrum (Electrospray LC/MS): Found 422 (MH^+). $C_{24}H_{27}N_3O_2S$ requires 421.

Example 3: (RS)-2-(2-(4-Fluoro)phenoxyethyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)piperazine

A mixture of (RS)-2-(2-(4-fluoro)phenoxyethyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-4-trifluoroacetyl piperazine (product of example 1) (0.18 g, 0.35 mmol) and potassium carbonate (0.3

g, 2.17 mmol) in methanol (6 ml) and water (2 ml) were heated at 80 °C for 2h. On cooling the reaction mixture was evaporated *in vacuo* and the residue partitioned between dichloromethane (30 ml) and 1N sodium hydroxide (30 ml). The aqueous layer was extracted with dichloromethane (2 x 30 ml), the combined organics dried (Na₂SO₄) and evaporated *in vacuo* to afford the title compound as a brown gum (0.11 g, 74 %). Mass spectrum (AP⁺): Found 426 (MH⁺). C₂₃H₂₄FN₃O₂S requires 425.

Example 4: (RS)-4-Methyl-2-(2-phenoxyethyl)-1-((2-phenyl)benzamido)-piperazine

The title compound (0.34g, 85%) was obtained from the compound of D10 (0.022g, 0.1 mmol) and 2-phenylbenzoyl chloride (0.022g, 0.1 mmol) as described for Example 2. Mass spectrum (Electrospray LC/MS): Found 401 (MH⁺). C₂₆H₂₈N₂O₂ requires 400.

Example 5: (RS)-4-(Benzyloxycarbonyl)-1-((2-(3-methyl-[1,2,4]-oxadiazol-5-yl)-phenyl)carbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.138g, 81%) was obtained from the compound of D16 (0.11g, 0.32 mmol) and 2-(3-methyl-[1,2,4]-oxadiazol-5-yl)benzoyl chloride (0.079g, 0.36 mmol) according to the method of Example 2. Mass spectrum (Electrospray LC/MS): Found 527 (MH⁺). C₃₀H₃₀N₄O₅ requires 526.

Example 6: (RS)-4-(Benzyloxycarbonyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.16g, 91 %) was obtained from the compound of D16 (0.11g, 0.32 mmol) and 2-methyl-5-phenylthiazole-4-carbonyl chloride (0.086g, 0.36 mmol) according to the method of Example 2. Mass spectrum (Electrospray LC/MS): Found 542 (MH⁺). C₃₁H₃₁N₃O₄S requires 541.

Example 7: (RS)-4-(Methoxycarbonyl)-1-((2-phenyl)benzamido)-2-(2-phenoxyethyl)piperazine

The title compound (0.027g, 80 %) was obtained from the compound of D9 (0.02g, 0.076 mmol) and 2-phenylbenzoyl chloride (0.026g, 0.12 mmol) according to the method of Example 2. Mass spectrum (AP⁺): Found 445 (MH⁺). C₂₇H₂₈N₂O₄ requires 444.

Example 8: (RS)-4-(Methoxycarbonyl)-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.031g, 88 %) was obtained from the compound of D9 (0.02g, 0.076 mmol) and 2-methyl-5-phenylthiazole-4-carbonyl chloride (0.029g, 0.12 mmol) according to the method of Example 2. Mass spectrum (AP⁺): Found 466 (MH⁺). C₂₅H₂₇N₃O₄S requires 465.

Example 9: (RS)-4-(Methoxycarbonyl)-1-((1-naphthyl)carbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.019g, 59 %) was obtained from the compound of D9 (0.02g, 0.076 mmol) and 1-naphthylcarbonyl chloride (0.023g, 0.12 mmol) according to the method of Example 2. Mass spectrum (AP⁺): Found 419 (MH⁺). C₂₅H₂₆N₂O₄ requires 418.

Example 10: (RS)-4-Acetyl-1-((4-(2-methyl-5-phenyl)thiazolyl)carbonyl)-2-(2-phenoxyethyl)piperazine

The title compound (0.059g, 88 %) was obtained from the compound of D19 (0.037g, 0.149 mmol) and 2-methyl-5-phenylthiazole-4-carbonyl chloride (0.043g, 0.179 mmol) according to the method of Example 2. Mass spectrum (AP^+): Found 450 (MH^+). $C_{25}H_{27}N_3O_3S$ requires 449.

Example 11: (RS)-1-((2-Phenyl)benzamido)-2-(2-phenoxyethyl)piperazine acetate

The compound of D20 (0.1g, 0.19 mmol) in ethanol (10 ml) containing g. acetic acid (1 ml) was hydrogenated at NTP over 10 % Pd/C (60 % aq. paste) (0.03g) for 5h. The resultant was filtered through kieselguhr, washed with ethanol and the filtrate evaporated to afford the title product (0.07g, 80 %). Mass spectrum (Electrospray LC/MS): Found 387 (MH^+). $C_{25}H_{26}N_2O_2$ requires 386.

It is understood that the present invention covers all combinations of particular and preferred groups described herein above.

Determination of Orexin-1 Receptor Antagonist Activity

The orexin-1 receptor antagonist activity of the compounds of formula (I) was determined in accordance with the following experimental method.

Experimental Method

HEK293 cells expressing the human orexin-1 receptor were grown in cell medium (MEM medium with Earl's salts) containing 2 mM L-Glutamine, 0.4 mg/mL G418 Sulphate from GIBCO BRL and 10% heat inactivated fetal calf serum from Gibco BRL. The cells were seeded at 20,000 cells/100 μ l/well into 96-well black clear bottom sterile plates from Costar which had been pre-coated with 10 μ g/well of poly-L-lysine from SIGMA. The seeded plates were incubated overnight at 37°C in 5% CO_2 .

Agonists were prepared as 1 mM stocks in water:DMSO (1:1). EC_{50} values (the concentration required to produce 50% maximal response) were estimated using 11x half log unit dilutions (Biomek 2000, Beckman) in Tyrode's buffer containing probenecid (10 mM HEPES with 145mM NaCl, 10mM glucose, 2.5 mM KCl, 1.5 mM $CaCl_2$, 1.2 mM $MgCl_2$ and 2.5mM probenecid; pH7.4). Antagonists were prepared as 10 mM stocks in DMSO (100%). Antagonist IC_{50} values (the concentration of compound needed to inhibit 50% of the agonist response) were determined against 3.0 nM human orexin-A using 11x half log unit dilutions in Tyrode's buffer containing 10% DMSO and probenecid.

On the day of assay 50 μ l of cell medium containing probenecid (Sigma) and Fluo3AM (Texas Fluorescence Laboratories) was added (Quadra, Tomtec) to each well to give final concentrations of 2.5 mM and 4 μ M, respectively. The 96-well plates were incubated for 90 min at 37°C in 5% CO_2 . The loading solution containing dye was then aspirated and cells were washed with 4x150 μ l Tyrode's buffer containing probenecid and 0.1% gelatin (Denley Cell Wash). The volume of buffer left in each well was 125 μ l. Antagonist or buffer (25 μ l) was added (Quadra) the cell plates gently shaken and incubated at 37°C in 5% CO_2 for 30 min. Cell plates were then transferred to the Fluorescent Imaging Plate Reader (FLIPR, Molecular Devices) instrument and maintained at 37°C in humidified air. Prior to drug addition a single image of the cell plate was taken (signal test), to evaluate dye loading consistency. The run protocol used 60 images taken at 1

second intervals followed by a further 24 images at 5 second intervals. Agonists were added (by the FLIPR) after 20 sec (during continuous reading). From each well, peak fluorescence was determined over the whole assay period and the mean of readings 1-19 inclusive was subtracted from this figure. The peak increase in fluorescence was plotted against compound concentration and iteratively curve fitted using a four parameter logistic fit (as described by Bowen and Jerman, *TIPS*, 1995, **16**, 413-417) to generate a concentration effect value. Antagonist K_b values were calculated using the equation:

$$K_b = IC_{50} / (1 + ([3/EC_{50}]))$$

where EC_{50} was the potency of human orexin-A determined in the assay (in nM terms) and IC_{50} is expressed in molar terms.

Compounds of Examples tested according to this method had pK_b values in the range 7.0 – 8.5 at the human cloned orexin-1 receptor.

The orexin-2 receptor antagonist activity of the compounds of formula (I) is determined in accordance with the following experimental method.

Experimental Method

CHO-DG44 cells expressing the human orexin-2 receptor were grown in cell medium (MEM medium with Earl's salts) containing 2 mM L-Glutamine, 0.4 mg/mL G418 Sulphate from GIBCO BRL and 10% heat inactivated fetal calf serum from Gibco BRL. The cells were seeded at 20,000 cells/100 μ l/well into 96-well black clear bottom sterile plates from Costar which had been pre-coated with 10 μ g/well of poly-L-lysine from SIGMA. The seeded plates were incubated overnight at 37C in 5% CO_2 .

Agonists were prepared as 1 mM stocks in water:DMSO (1:1). EC_{50} values (the concentration required to produce 50% maximal response) were estimated using 11x half log unit dilutions (Biomek 2000, Beckman) in Tyrode's buffer containing probenecid (10 mM HEPES with 145mM NaCl, 10mM glucose, 2.5 mM KCl, 1.5 mM $CaCl_2$, 1.2 mM $MgCl_2$ and 2.5mM probenecid; pH7.4). Antagonists were prepared as 10 mM stocks in DMSO (100%). Antagonist IC_{50} values (the concentration of compound needed to inhibit 50% of the agonist response) were determined against 10.0 nM human orexin-A using 11x half log unit dilutions in Tyrode's buffer containing 10% DMSO and probenecid.

On the day of assay 50 μ l of cell medium containing probenecid (Sigma) and Fluo3AM (Texas Fluorescence Laboratories) was added (Quadra, Tomtec) to each well to give final concentrations of 2.5 mM and 4 μ M, respectively. The 96-well plates were incubated for 60 min at 37C in 5% CO_2 . The loading solution containing dye was then aspirated and cells were washed with 4x150 μ l Tyrode's buffer containing probenecid and 0.1% gelatin (Denley Cell Wash). The volume of buffer left in each well was 125 μ l. Antagonist or buffer (25 μ l) was added (Quadra) the cell plates gently shaken and incubated at 37C in 5% CO_2 for 30 min. Cell plates were then transferred to the Fluorescent Imaging Plate Reader (FLIPR, Molecular Devices) instrument. Prior to drug addition a single image of the cell plate was taken (signal test), to evaluate dye loading consistency. The run protocol used 60 images taken at 1 second intervals followed by a further 24 images at 5 second intervals. Agonists were added (by the FLIPR) after 20 sec (during continuous reading). From each well, peak fluorescence was determined over the whole assay period and the

mean of readings 1-19 inclusive was subtracted from this figure. The peak increase in fluorescence was plotted against compound concentration and iteratively curve fitted using a four parameter logistic fit (as described by Bowen and Jerman, *TIPS*, 1995, 16, 413-417) to generate a concentration effect value. Antagonist Kb values were calculated using the equation:

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$$K_b = IC_{50} / (1 + ([3/EC_{50}]))$$

where EC₅₀ was the potency of human orexin-A determined in the assay (in nM terms) and IC₅₀ is expressed in molar terms.

Compounds of Examples tested according to this method had pkb values of less than 7 at the human orexin-2 receptor.

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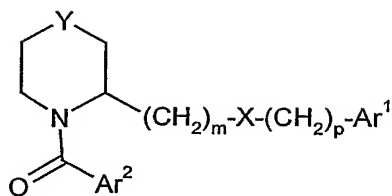
Throughout the specification and the claims which follow, unless the context requires otherwise, the word 'comprise', and variations such as 'comprises' and 'comprising', will be understood to imply the inclusion of a stated integer or step or group of integers but not to the exclusion of any other integer or step or group of integers or steps.

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The application of which this description and claims forms part may be used as a basis for priority in respect of any subsequent application. The claims of such subsequent application may be directed to any feature or combination of features described herein. They may take the form of product, composition, process, or use claims and may include, by way of example and without limitation the following claims:

CLAIMS

1. A compound of formula (I):



(I)

wherein:

Y represents NR²;

m represents 1, 2, or 3;

p represents 0 or 1;

X is O, S, C=O, SO₂, or -CH=CH-;

Ar¹ is aryl, or a mono or bicyclic heteroaryl group containing up to 4 heteroatoms selected from N, O and S; any of which may be optionally substituted;

Ar² represents phenyl or a 5- or 6-membered heterocyclyl group containing 1 to 3 heteroatoms selected from N, O and S, wherein the phenyl or heterocyclyl group is substituted by R¹ and further optional substituents; or Ar² represents an optionally substituted bicyclic aromatic or bicyclic heteroaromatic group containing 1 to 4 heteroatoms selected from N, O and S;

R¹ represents optionally substituted(C₁₋₄)alkoxy, halo, optionally substituted(C₁₋₆)alkyl, optionally substituted phenyl, or an optionally substituted 5- or 6-membered heterocyclic ring containing 1 to 4 heteroatoms selected from N, O and S;

R² represents hydrogen, optionally substituted (C₁₋₄)alkyl, optionally substituted (C₁₋₆)alkanoyl, optionally substituted (C₁₋₆)alkanoxycarbonyl or optionally substituted (C₁₋₆)alkylaryloxycarbonyl;

or a pharmaceutically acceptable salt thereof.

2. A compound as claimed in claim 1 wherein R² represents hydrogen, methyl, ethyl, acetyl, trifluoroacetyl, methoxycarbonyl or benzyloxycarbonyl.

3. A compound as claimed in claim 1 or 2 wherein Ar² represents optionally substituted phenyl, pyridinyl, thiazolyl, pyrazolyl, pyridazinyl, 1,2,3-triazolyl or naphthyl.

4. A compound as claimed in any preceding claim wherein R¹ represents a trifluoromethoxy, methoxy, halo, or an optionally substituted phenyl, pyridinyl, pyrazolyl, oxadiazolyl, or pyrimidinyl group

5. A compound as claimed in any preceding claim wherein Ar¹ represents is an optionally substituted phenyl.

6. A compound as claimed in any preceding claim wherein m is 2 and p is 0.

7. A compound as claimed in any preceeding claim wherein X is O.

5 8. A compound as claimed in any preceding claim wherein Ar² is optionally substituted by halogen, cyano, or optionally substituted (C₁₋₆)alkyl.

9. A compound as claimed in any one of Examples 1 to 11.

10 10. A pharmaceutical composition comprising a compound of formula (I) as defined in any one of claims 1 to 9, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

15 11. A method of treating or preventing diseases or disorders where an antagonist of a human orexin receptor is required, which comprises administering to a subject in need thereof an effective amount of a compound of formula (I) as defined in any one of claims 1 to 9, or a pharmaceutically acceptable salt thereof.

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/11316

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61K31/495 C07D241/04 C07D417/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61K C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 02 44172 A (BRANCH CLIVE LESLIE ;JOHNSON CHRISTOPHER NORBERT (GB); SMITH ALEXA) 6 June 2002 (2002-06-06) cited in the application the whole document ---	1-11
P,A	WO 01 96302 A (BRANCH CLIVE LESLIE ;JOHNSON CHRISTOPHER NORBERT (GB); THEWLIS KEV) 20 December 2001 (2001-12-20) cited in the application the whole document ----	1-11
E	WO 02 090355 A (BRANCH CLIVE LESLIE ;JOHNSON CHRISTOPHER NORBERT (GB); THEWLIS KEV) 14 November 2002 (2002-11-14) the whole document ----- -/--	1-11



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

5 December 2002

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/11316

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 02/11316

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